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Synecococcus sp.: See p. 17





BIRCH BARK BASKETS

This remarkable material is still worked by the Manouane Indians of Quebec

by Aliko Podolinsky Webber© 1973
photos by Ray Webber

The paper birch (*Betula papyrifera*) is found in a broad swath across the North American continent, from Newfoundland and the Atlantic coast to British Columbia, the Yukon, and Alaska ; from the northern United States almost to the treeline. It is one of the most beautiful trees in Canada, exceptional for its unusual bark – smooth, layered and silvery. But for the Indians of times past it was much more than a beautiful tree ; its bark was an integral part of their lives, an adaptable material that could be worked into many forms – canoes, of course, but also roofs for their wigwams, as well as pails, pots, dishes, spoons, masks, toys, headbands, boxes and containers of all kinds – the sort of things made of skins in the treeless tundra and the plains. The Indians considered the birch tree sacred and believed that the gods had created the tree and given them the knowledge of its many uses and the hidden structure and magical properties of its outer shell.

The birch-bark containers seen on the cover and on these pages were made recently by the people of Manouane, one of the three surviving sub-bands of the Têtes de Boule tribe whose home is in the upper Saint-Maurice region of Quebec. Containers like these are still being made in the traditional ways, although the particular containers illustrated here are part of a collection made for the Quebec government, which is systematically gathering examples of all types of Indian and Eskimo crafts indigenous to the province. These containers have all been executed in the

time-honored manner – none of the old skills have been lost. Using only a knife and an awl as tools, these Indians still make every shape and design of container used by their ancestors.

It is usual for the men to be responsible for making canoes while the women make the containers and other smaller objects. However, there are exceptions to this division of labor ; women often help with canoe-building while the men may occupy themselves with making some of the smaller articles.

Heavy bark from the tallest trees – up to 80 feet in height – was used to build the canoes, both the large war canoes and the smaller hunting canoes. Thinner layers of bark were fashioned into smaller objects and utensils. Although the bark is highly inflammable, containers made from freshly cut bark could be used as cooking pots over open fires fueled by the same bark ; the pots were frequently dampened to prevent them from drying out and burning. The Indians believed that the bark had preserving qualities ; food was often stored in bark containers for long periods, and the bodies of the dead were wrapped reverently in its layers.

Some anthropologists believe that the origins of the birch-bark containers are inseparably linked with the gathering of maple sap and the making of syrup. It is not known how the Indians first discovered that the spring sap of the maple tree could be boiled down to make sweet



Mature birch forests are hard to find in the Manouane area. Indians sometimes travel up to 50 miles to find suitable trees

*Algonkian César Newashish collects bark with a penknife.
Size of the strip determines the basket's finished proportions*



syrup, but it is clear that containers were needed to collect the sap and to boil and store it – and the containers they used were made of birch bark.

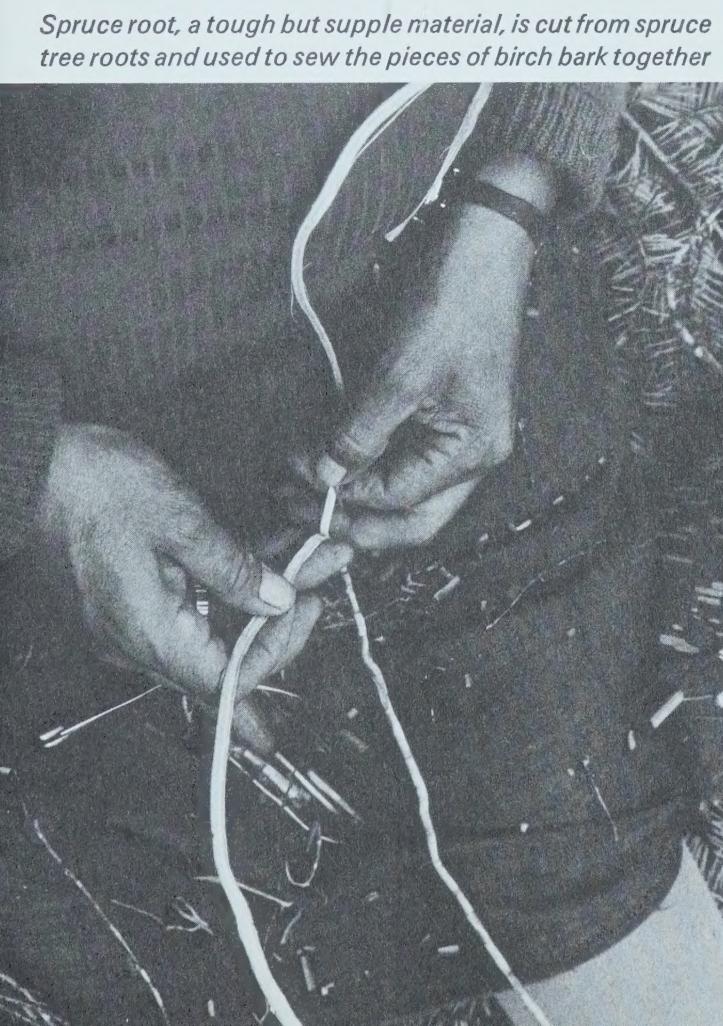
Unlike the ceramic, stone, or metal objects used by other primitive people and unearthed in later years by archeologists, few of the birch-bark articles made by the early Indians have survived. Because it is an organic material, birch bark decays rapidly in use, making it an environmentalist's dream but a problem for anthropologists who are studying the past culture of the people.

After contact with white culture, the Indians' life style changed radically and birch bark was gradually replaced with man-made materials of the white civilization. But, fortunately, the ancient craft of fashioning this wonder material of nature into functional and beautiful objects has not been entirely lost. In some tribes the art of working birch bark has been passed from one generation to another until the present time. The Têtes de Boule have been known to white people since the early days of New France, but it is only comparatively recently that their contact with white civilization has been intense. A Hudson's Bay post was established at the Manouanes' summer rallying place in 1837, the tribe's most southern settlement. In 1871 the first missionary arrived in the area, although the Manouanes had encountered priests much earlier in their nomadic wandering from place to place. Only in the 1950s did the Manouane Indians leave their tent dwellings for more modern houses; even now tents can be seen beside some of the houses – their owners explain that they feel they can sleep better in the tents. Just this year an all-weather road has been completed, linking the community to the nearest town, Saint-Michel des Saints, 50 miles away.

About 850 Indians now live in Manouane. Some of them make a living as loggers or fishing guides; a few have jobs with the Hudson's Bay post, but there are few opportunities for employment. The Têtes de Boule Indians were semi-nomadic hunters, and although their life and environment have changed greatly, some of the old skills and customs



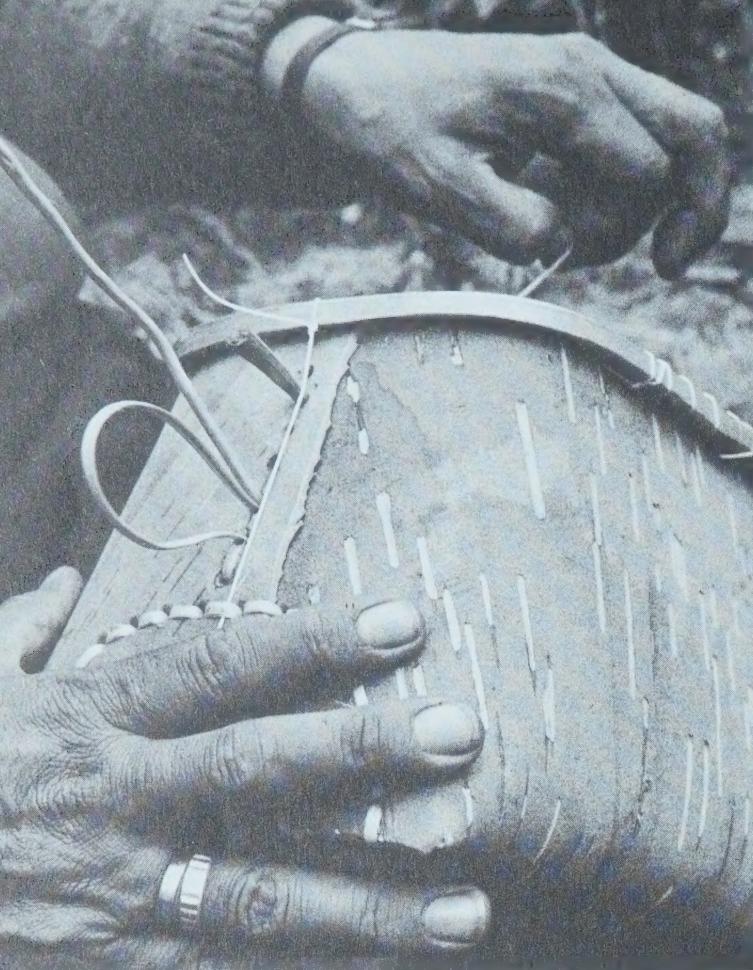
Unblemished bark is removed carefully, then rolled tightly and stored in a cool place if it's not used right away



Spruce root, a tough but supple material, is cut from spruce tree roots and used to sew the pieces of birch bark together

The cleaned root is flattened and given a sharp tip for easy sewing. A machine-made awl is used to punch thread holes





Spruce root must be kept wet while the basket is being made; once it dries out it gets hard and too stiff to work with



The rim hoop is whittled from a green branch then bent, tied and hung to dry. In place, it will give the container support

Mrs. César Newashish, one of the few Algonkians still working birch bark, takes about a day to cut and shape a container



*All containers at the top were made by Mrs. Edmond Ottawa;
in the centre by Mrs. César Newashish and
at the bottom by Mrs. Jimmy Boivin*

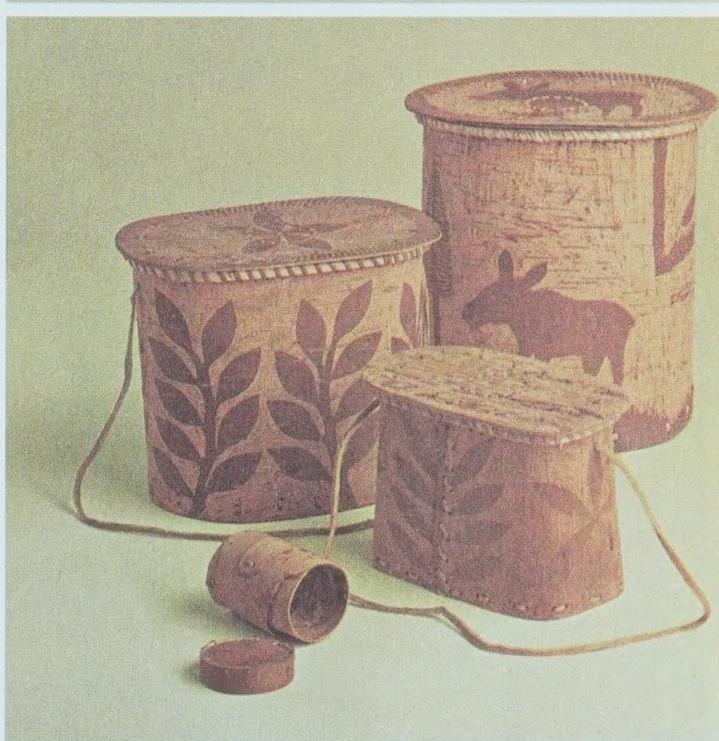
remain. Many of the Manouane Indians still occupy themselves with the ancient craft of creating birch-bark objects.

The intricate process of birch-bark working begins when the bark is harvested – cut and peeled carefully from the tree. Freshly cut bark can be bent into the desired shape quite easily, but if the bark has dried out it has to be heated and dampened to make it pliable. When it cools it is tough and firm enough to retain the shape into which it has been formed. The article is then sewn with strands of spruce root – a tough but supple thread. The shape of the piece of bark determines the proportions of the container, so there is no trimming or waste, but infinite variation. There are half a dozen different shapes.

The next step in the creative process is decoration. When the bark is peeled from the tree in late winter or early spring, a thin, dark substance coats the inside surface. This substance can easily be scraped off when moistened, exposing the underlying lighter layer. The Indians often use templates cut from pieces of bark as guides for transferring a design onto the container.

The incised designs are of three kinds – geometric patterns, which are symmetrically placed on the sides and covers of containers ; leaf, flower and tree designs, which are also given symmetrical treatment ; and images of birds and animals. The Indians say that their designs are often seen in dreams and visions and that they reveal the spiritual forms of the plants and animals they depict.

The significance of the design is usually known only to its maker, who is likely to be reluctant to explain. However, it is known that medicinal plants and animals that the Indians hunt for food are often portrayed on birch bark in the belief that this will ensure a steady supply. The Indians use a large number of plants medicinally and the portrayal of the plant on birch bark is part of the treatment. Some of the plants are now the subject of medical research. The design on the largest box shown on the cover illustration represents a medical plant that César Newashish, a master canoe-builder and son of one of the last hereditary chiefs, has used all his life. □



Alika Podolinsky Webber is an anthropologist whose special interest is the decorative design of native crafts and the significance of these designs to their makers. She has worked with the northeastern Algonkian Indians for more than a decade.

She visited Manouane in the upper Saint-Maurice district of Quebec early this year.

Permafrost

It can be rock, gravel, sand or silt, and it's no trouble, really, so long as it stays frozen

by Jean Martin

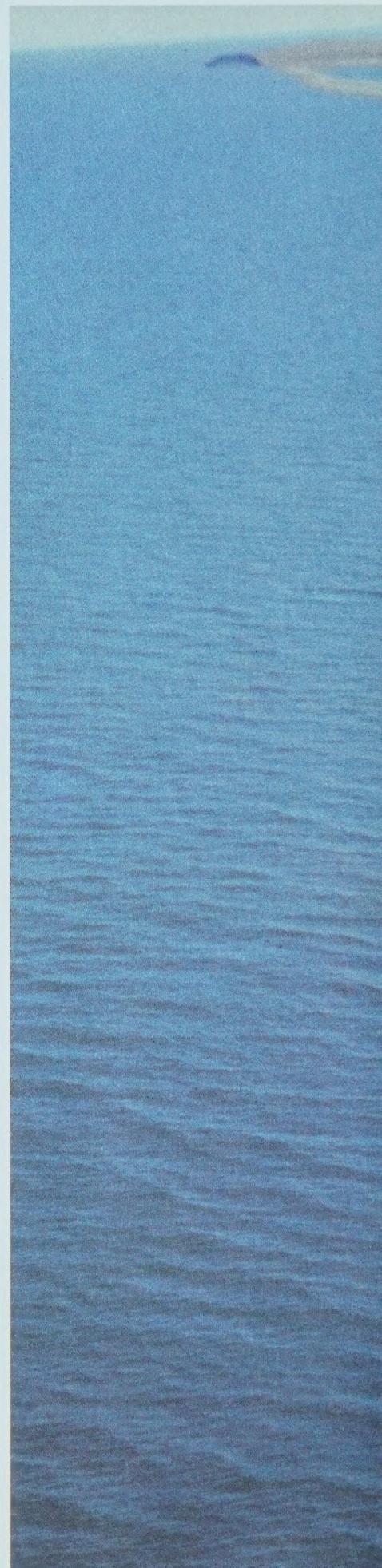
The image of Canada as a land of ice and snow has a solid basis in fact. Half the country's ground is gripped permanently in a freeze deeper than any home refrigerator can provide. The condition is known as permafrost, and it's difficult to work with, delicately balanced, seasonally adjustable and the most important factor facing anybody who wants to operate in the North. It includes all types of ground from soggy peat bogs through gravel mounds to solid rock. And despite its fearsome reputation, anything can be built on permafrost that can be built anywhere else. The trick is understanding the stuff and taking its properties into account first.

'Its properties vary tremendously within short horizontal and vertical distances,' says Dr. Jack Clark, soft-

spoken supervisor of earth sciences for Northern Engineering Services Company Limited. 'But permafrost soil is not really a lot different from the soil you'd find in warmer regions unless it has a high ice content.'

According to Dr. Clark, a 17-year veteran of dealing with permafrost, the ice in the soil gives it more strength than it would normally have. And many engineering problems can be avoided simply by preserving the ground in its frozen state. 'If ice-rich permafrost is kept intact it's virtually like solid rock. You can build anything on permafrost that you could build on unfrozen soils, provided you have a proper design,' says Dr. Clark.

But the reverse is true when the permafrost thaws. If ground ice forms a large proportion of the soil volume, it



Tom Watmore



Ice-laden permafrost breaks from the shores of Pelly Island, five miles west of Imperial's artificial drilling island in the Beaufort Sea



■ CONTINUOUS PERMAFROST ZONE
■ DISCONTINUOUS PERMAFROST ZONE

turns to water creating a slurry. 'When ice reverts to water the ground loses its stability,' explains Dr. Clark. 'In the thawed state it may have little or none of its former strength left.'

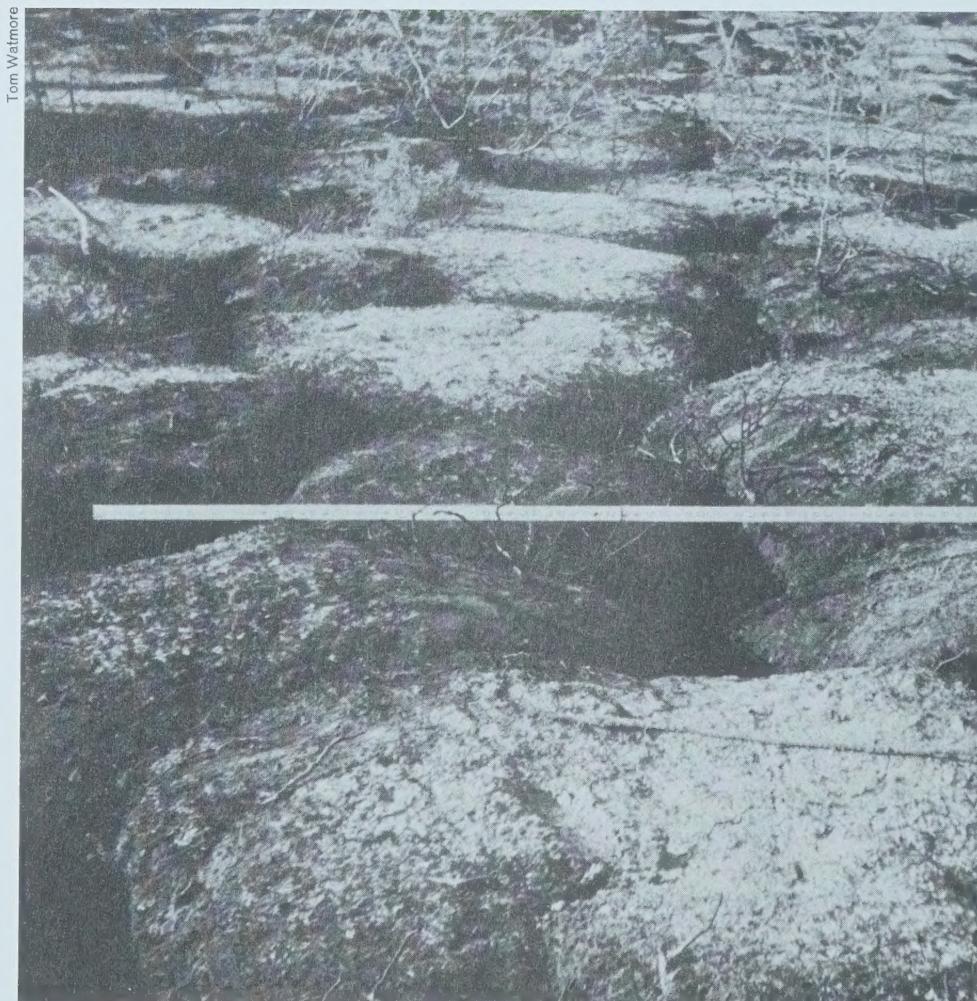
Significantly, a well-drained soil like sand or gravel is not normally subject to the same hazards as a fine, silty soil. In well-drained soils and in soils with a low ice content thawing does not result in lost volume. As an example Dr. Clark tells of the Canol Road, built during the Second World War from Norman Wells over 620 miles of permafrost to Whitehorse. After almost 30 years the road, abandoned at war's end, is still intact.

While permafrost can present some unusual problems, its origin is simple. If ground material, such as rock and soil, remain frozen for at least one complete year, they qualify as permafrost even if the condition is not sustained longer. Dr. Roger Brown, of the National Research Council of Canada, explains that the frozen condition will penetrate deeper each year as long as the same climatic conditions prevail. The resulting thickening is a slow process and scientists studying the permafrost on Cornwallis Island in the Northwest Territories calculate it penetrated to a depth of 1,300 feet at Resolute over

a period of 10,000 years. Does this growing ever stop? 'Yes, it does,' says Dr. Brown. 'Somewhere far below the earth's surface, heat from the planet's core will eventually balance the cold.'

In Canada, the greatest thickness of permafrost is in the Arctic region where the summers are brief and the winters long and severe. In this land the freezing has spread to every stone and clump of earth with the single exception of those beneath bodies of water that don't freeze to the bottom. It is known as continuous permafrost, a condition that at its extreme extends southward almost 2,000 miles from the northern tip of Ellesmere Island in the high Arctic to the southern edge of Hudson Bay.

In the West, the southern edge of this zone crosses the Mackenzie River in the vicinity of Arctic Red River. From there it begins a shallow arc to the southeast past the north shore of Great Bear Lake into Manitoba and around the tip of Hudson Bay to the mouth of James Bay. Farther east it crosses northern Quebec and southern Baffin Island. South of



Bumpy-looking tundra is a result of frost-heaving in the soil and is typical of the formations found on permafrost. In this instance, fire has stripped away the vegetative covering

this area of total cover the permafrost becomes patchy and, according to Dr. Brown, is no more than 200 feet deep. The patches are large and widespread at the northern edge of this 'discontinuous zone'; they get smaller and thinner until the zone fades out at various points inside the provinces.

Overlying Canada's permafrost is a thin blanket of earth that reacts to the changes of the seasons. Because it freezes and thaws annually, scientists call this cap of earth the active layer. According to Dr. Brown: 'It's not actually a part of the permafrost but rather a medium for the exchange of heat and moisture between the permafrost and the atmosphere. Its characteristics and its behavior, when disturbed, have to be considered in the design and construction of anything built on permafrost.'

In patchy permafrost the active layer ranges from two to 10 feet deep but in the continuous zone the depth will vary only from one-and-a-half to three feet. Local variations in the layer's thickness depend on such things as vegetation, drainage, snow cover as well as soil type. Vegetation is one of these factors most easily altered by man. Very often, a delicate balance exists between the ground and the atmosphere, one that is controlled by an insulating mat of grasses, moss and small plants. In patchy or discontinuous permafrost, for instance, frozen ground can generally be found under mounds of peat. In summer, when it is dry, the peat will insulate the ground from the sun's heat, but in winter the peat becomes moist and offers little resistance to the cold. If the peat is removed the underlying ground loses its protection. 'And it's often in a very delicate state,' explains Dr. Brown. 'The ground temperature might only be a fraction of a degree below freezing. Any rise in temperature will likely cause it to thaw.'

Such a rise occurred when a forest fire threatened Inuvik in 1968. Firefighters had to strip the vegetation from some 25 miles of fire breaks in an effort to save the town. Now, there are trenches as deep as 10 feet in the cleared areas where the ground thawed and slumped — a condition that occurs when the ice in the soil melts, reducing the soil's volume so that it contracts to fill a smaller space.

Today, knowledge about permafrost is increasing rapidly, but for centuries it was little known and even less understood. Explorer Martin Frobisher had to deal with it when he arrived in Canada

Tom Walmore



Ice sometimes makes up a large part of the permafrost soil, only a thin top layer thaws in summer. Kept frozen, ice-rich permafrost will support buildings as well as solid rock

in 1576. Besides a northwest passage, Frobisher was looking for gold on Baffin Island, but preliminary excavations were thwarted when he encountered frozen ground.

Then in the 18th century, James Isham noted in his 'Observations on Hudson's Bay, 1743' that even in summer it was difficult to dig very far into the ground. He wrote: '...the frost is never out of the ground in these parts.'

At the close of the 18th century and throughout most of the 19th, only scattered observations were made, mostly by fur traders and explorers. To that

time, little settlement had taken place in the North. Roads were almost non-existent and the simple buildings that were erected had little effect on the permafrost.

Then, in 1889, the Royal Geographical Society's permafrost committee produced the most ambitious report on frozen ground completed to that period. Attempts had been made to determine the depth of permafrost and its geographical limits through observations at 22 different locations. And about the time of the report, according to Dr. Brown, American whalers were using perma-



Canadian Arctic Gas Study Limited

Test trenches reveal how the permafrost will react during construction of an Arctic pipeline

frost pits along the Canadian Arctic coast to deep-freeze their whale meat. These pits were excavated in soils with little ice and then insulated with a cover of organic material such as peat or moss. Properly insulated, the pits would keep their contents frozen indefinitely. In the Klondike gold rush of 1896 prospectors often had to thaw the ore before they could get it out of the ground.

Following World War I, interest in permafrost was renewed by the development of petroleum reserves at Norman Wells and the building of the Hudson Bay railroad from Winnipeg to Churchill, Man. In both instances, engineers soon learned that permafrost could not be overlooked. Thawing of the ice-rich soil and extreme frost heaving cracked floors and walls in the build-

Canadian Arctic Gas Study Limited



Canadian Arctic Gas Study's Sans Sault test site is helping to determine effects of buried and elevated pipelines on permafrost

ings at Norman Wells and twisted rail beds out of shape on the Hudson Bay line. As a result, new techniques were devised to combat the damaging effects of permafrost.

'With the arrival of World War II, little time was left for permafrost study,' says Dr. Brown. 'Much of the emergency construction in the North during that period had to be carried out on a rather hit and miss basis. The result was that many of the projects, such as airfields, were heavily damaged by frost action and serious drainage problems.'

In 1950, the National Research Council of Canada set up a permafrost section and initiated an intensive study of Canada's permafrost region. The same year, studies were underway to determine the extent of permafrost and



Canadian Arctic Gas Study Limited



Big balloon tires avoid damage to the thin blanket of vegetation that insulates the permafrost

Terry Watmore



When vegetation is stripped off, ice-rich permafrost thaws and slumps, leaving a mud hole

the best methods of dealing with it. Today, information about frozen soils is being exchanged through a network of government agencies and other organizations whose activities take them into Canada's northland. Information is also being exchanged between the National Research Council and agencies in the USSR. In Siberia, recently, an international conference was held at Yakutsk, a city on continuous permafrost.

Since the early 1960s oil exploration in Alaska and in Canada's Mackenzie Delta and Arctic Islands has increased

rapidly, creating a need for more roads and larger settlements.

As the size of structures grew, buried foundations became a necessary part of their design. Says Dr. Brown: 'Prior to about 1960, most buildings were small and lightweight. They could tolerate the movement that accompanied the thawing of ice-rich soils. Structures were simply jacked level and then wedged with either wood or stone. People looked on it as nothing more than regular maintenance—that is, if they did it at all.'

Today, a number of construction

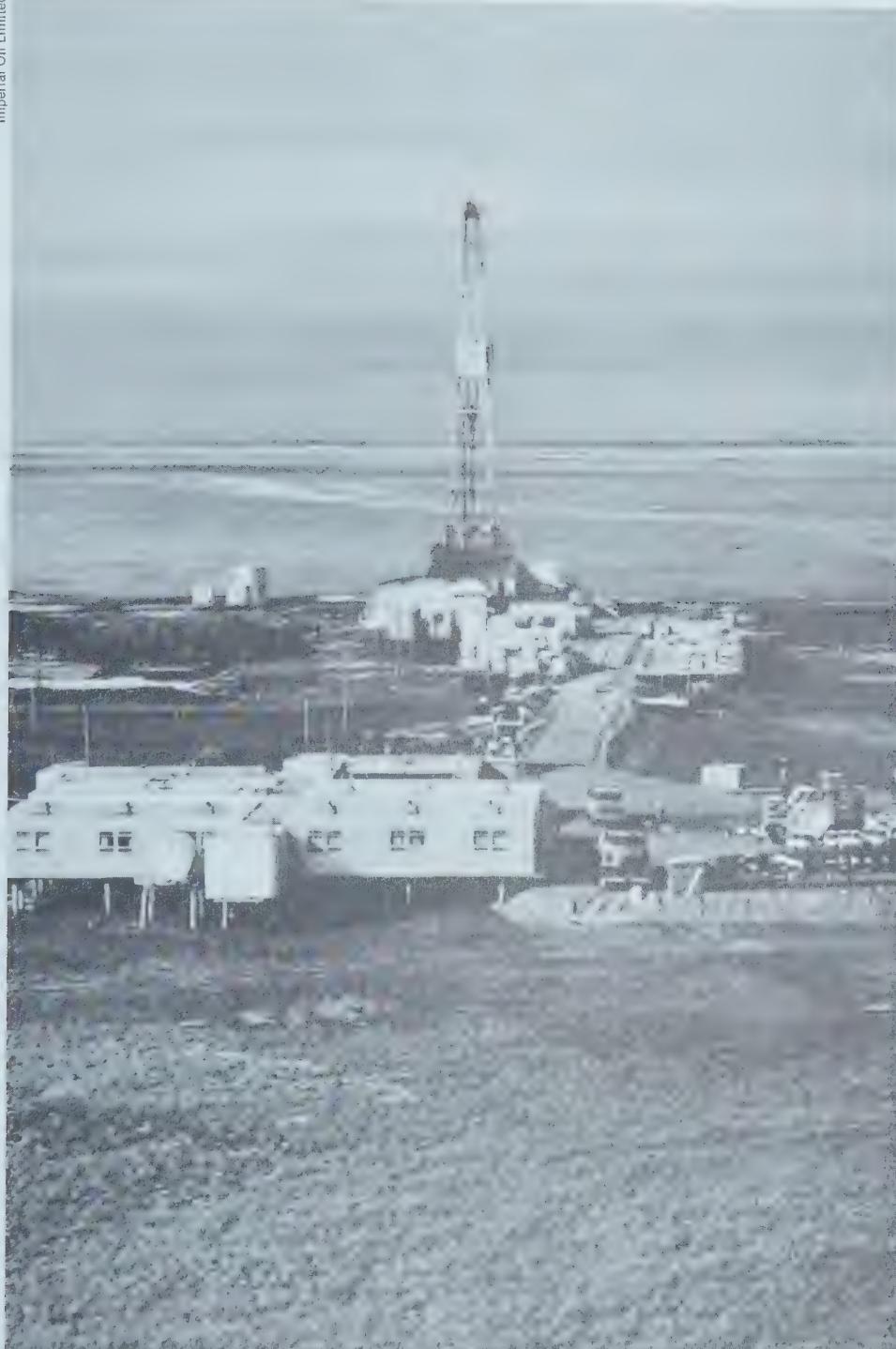
methods are used to build safely on permafrost. Of the techniques used, concrete and wood piles have emerged as the most popular. With this method, the structure is raised off the ground so that the space underneath allows cold air to circulate freely.

By comparison, some structures are built to sit right on the ground surface on wood mats or concrete slabs. In other instances, gravel foundations, up to four and five feet thick are used to serve the same purpose.

Sewer and water supply systems, in



In large northern settlements like Inuvik, sewers and water supply are protected from freezing in above-ground, insulated boxes called utilidors



For drilling on permafrost, Imperial places rigs and buildings on piles or gravel pads

some large centres like Inuvik, are carried in above-ground, insulated boxes called utilidors. These protected corridors, sometimes buried if the soil is coarse and ice-free, protect the pipes from freezing and the permafrost from melting. Often, the two major services share space with such things as steam, gas, power and telephone lines. Utilidors are efficient, but they are so expensive that only large settlements can afford them. At places like Resolute, water comes in by tank truck; sewage

goes out in plastic bags.

At its operating sites in the Mackenzie Delta and the Arctic Islands, Imperial is faced with all the problems that permafrost presents. 'It affects everything the company does,' says Alex Hemstock, director of environmental studies for Canadian Arctic Gas Study Limited (CAGSL). Hemstock, on loan to CAGSL since Jan. 1, 1973, was Imperial Oil's Arctic co-ordinator with the responsibility to ensure that company operations had a minimum effect on the

tundra. 'Over the years,' he adds, 'Imperial has made steady progress in learning to work harmoniously with the northern environment.'

Imperial's drill rigs, according to Hemstock, are supported on wooden piles or on thick gravel pads if there is a danger of disturbing the permafrost. Around the rig, where trucks and tractors operate, additional gravel helps to protect the ground surface. The pilings and gravel at each of its drill sites cost Imperial some \$300,000.

'But the main approach to protection of the tundra,' says Hemstock, 'is winter operation; then the ground is completely frozen. Ice and snow roads are built atop the frozen vegetation, leaving it undisturbed. The plows on bulldozers and graders are equipped with shoes so that blades do not gouge into the tundra. Vehicles travel on frozen lakes, rivers and coastal areas whenever they can, but even then, they are designed for reduced impact. Trucks are equipped with big tires that exert a low unit pressure on the ground and tracked vehicles are often used because their weight is distributed over a large area.'

During the drilling operation the permafrost is continuously protected. For this purpose, one of the first pieces of equipment to reach the drill site is the refrigerator. Its coils are placed in the space between the inner and outer 'strings' of casing, those lengths of pipe that drillers use to keep the drill hole from caving in. 'And if the well becomes a producer,' explains Hemstock, 'the coils are left so that the oil, coming to the surface hot, will not melt the permafrost.'

But long before the drills begin to probe the tundra, the search for oil has been complicated by permafrost. Seismic readings produced by shock waves are often misleading through ice-rich permafrost. Dr. Brown explains: 'The permafrost produces the same readings as solid rock and can confuse the seismic people if they're not aware it's below them. It's nothing but a nuisance.'

In addition to its effects on seismic echoes and exploratory drilling, permafrost is one of the principal factors that would affect a gas pipeline from the North. Engineers plan to lick that one by joining it. By chilling the gas below freezing temperature, the line will keep the permafrost frozen. At 1,500 miles, it will be the biggest refrigerator ever built. □



A huge dragline bites into a wall of tar sands 150 feet high at Syncrude Canada Ltd.'s Mildred Lake pilot facility on the Athabasca tar sands

Since you can't drill
producing wells in the
Athabasca tar sands,
oil men are turning
to other means

Digging for oil

by Steve Lynett

When explorer Peter Pond first saw the Athabasca tar sands nearly 200 years ago they played a small role in the area's industry. Cree Indians boiled out the oily substance found in the sand, mixed it with spruce gum and waterproofed their canoes. Over the years men have tried to extract the oil in larger quantities, but with little success. With the discovery of huge oil and gas reserves in the late 1940s, development of the costlier tar sands became uncertain.

Today, things have changed. As supplies of conventional oil and gas dwindle the tar sands have returned to the lime-light. Even now, oil produced in the tar

sands is being processed in Canadian refineries.

The tar sands are part of a 350-mile arc of oil-bearing sands in the north-eastern part of the province of Alberta. Estimators have calculated that as many as 800 billion barrels of oil may be locked in this arc of sands. The Athabasca deposit, by far the largest, could hold up to 600 billion barrels. But while prying all of this oil loose is next to impossible, even with new strides in technology, some 300 billion barrels may eventually be recovered. For comparison, Canada's known reserves of conventional crude are now rated at just

under 10 billion barrels.

Every year the need for energy is rising, not only in North America but throughout the world.

The world's two main energy sources – oil and natural gas – have been in great demand because of their desirable qualities. They are convenient, clean and relatively easy to transport. Other energy sources, notably coal, hydro and nuclear power, are plagued with various problems. Coal is subject to stringent sulfur emission standards, hydro is limited to sites that can be developed economically, and nuclear power development is hampered by a combina-

tion of adverse public reaction and plant construction problems.

Until recently, easily-produced liquid crude oil and natural gas have been cheap and plentiful. Throughout the last decade the world had the capacity to produce more crude than it needed. Competition among oil companies for markets has been keen and this has kept the price down. But, by the end of the 1960s the situation had begun to change. Greater industrial development, increases in population, and environmental pressure have sent the demand for these fuels skyrocketing. World crude prices, rising with this new demand, were forced even higher by sharply increased tanker rates. And these increased costs hit North Americans harder because of devalued dollars and inflation.

Canada will need oil, and lots of it, for many years to come and the tar sands with their large reserves will provide a steady supply even when conventional reserves begin to run out.

In the Athabasca region the land is predominantly jack pine and muskeg. Fort McMurray, an established, rural town of 8,000, about 250 miles northeast of Edmonton, sits roughly in the middle of the tar sands deposit.

In the surrounding countryside and throughout an area measuring some 12,000 square miles, the ground is interspersed with tar sands – a mix of sand, water and bitumen. The water and bitumen form a film around each of the individual sand grains and a gas, in most cases air, fills the spaces between. Along the banks of the Athabasca River the tar sands extend from the surface to a depth of about 150 feet. Farther away from the river, where most of the deposits are located, they can be buried as deep as 1,500 feet.

In the near-surface deposits, where up to 65 billion barrels of recoverable crude is stored, open-pit mining is best suited to the task of recovering the oil. The sand is mined and then taken to huge processing facilities where the bitumen is extracted. But for those sands lying under more than 300 feet of overburden, the mining technique is too expensive. Some method must be developed to extract the bitumen without removing the sand. Since the bitumen is extremely viscous, heating the reservoirs appears to be the only approach to recovering the oil. Once recovered, the bitumen can be converted to free-flowing syn-

thetic crude oil and pipelined to refineries for processing into petroleum products.

While recovery of the deeply-buried tar sands oil is still being developed, a commercial-sized plant is already mining the surface deposits. Operated by Great Canadian Oil Sands Limited, the plant, 23 miles from Fort McMurray, started producing synthetic crude oil in 1967 and last year reached an average daily output of some 51,000 barrels.

But a combination of economic and operating problems has plagued the pioneering venture. As yet there has been no return on the company's \$300-million investment. In 1972 the recorded loss was just under \$700,000 – almost unnoticed against the company's total accumulated losses of \$87 million. And while the rate of loss has lately been decreasing the company is still facing an Alberta royalty rate that the industry believes is too high. But even with lower royalties, a profitable venture, according to GCOS president Kenneth Heddon, depends on further increases in the price of crude oil.

And now a second company, Syncrude Canada Ltd., has announced plans to go ahead with a long-anticipated 125,000-barrel-per-day facility at Mildred Lake, 25 miles north of Fort McMurray. A four-company consortium, Syncrude is owned by Imperial Oil Limited, Atlantic Richfield Canada Ltd., and Canada-Cities Service Ltd., each of which own 30 per cent, and by Gulf Oil Canada Ltd., which owns 10 per cent.

While Imperial's research into tar sands development dates back some 30 years, the consortium was not formed until the late 1950s. Alberta, anxious to protect then-limited markets for conventional oil, turned down Syncrude's first plant application. As markets expanded towards the late 1960s, another application to erect an 80,000-barrel-per-day facility was approved. But as planning continued, it became clear that economics lay with large-scale operations, so in 1972 Syncrude looked for and got approval to step up to 125,000 barrels per day. At that point the company reserved its final decision until August, 1973 to allow time for negotiations over taxes, royalty rate, environmental factors and public participation in the venture.

Recently, plans were announced for a third tar sands mining facility, this

one to produce 100,000 barrels of synthetic crude oil a day. If government approvals and construction go as scheduled, the plant would be in operation by 1980.

While wide public awareness of the tar sands is a recent occurrence, men have known about them for centuries. And for the last 200 years a broad range of schemes has been tried to extract their oil. Many a man has lost his shirt in the process and today the skeletons of abandoned pilot plants can still be seen along the Athabasca Valley.

Peter Pond was the first white man to see the tar sands. He passed by them in the late 1770s in his canoe on a mission for the Hudson's Bay Company. Searching for a place to put a trading post he chose the present site of Fort McMurray, where the Athabasca and the Clearwater rivers meet.

In 1890, R. G. McConnell, of the Geological Survey of Canada, reported on them while investigating the Athabasca district. The first exploratory oil well was drilled there in 1897 and by the turn of the century news of the tar sands and their vast reserves of oil had spread right across the country. And for the next 60 years the region became a diary of frustrations recording one failure after another as a string of entrepreneurs tried to unlock the tar sands' riches.

Count Alfred von Hammerstein was one of the first. A German aristocrat, he heard about the tar sands while beating a path to the Klondike. And, since one fortune was as good as the next, the count decided to avoid the rush and prospect for oil instead. He theorized that if the sands were rich with oil there must be pools of it that could be reached by conventional drilling. After three unsuccessful wells at Poplar Island, six miles from Fort McMurray, the defeated count abandoned the tar sands, leaving them for someone else with a 'scheme'.

The search for oil pools continued as many more tried and failed. Then, in 1930, International Bitumen Company became the first to exploit the tar sands commercially. With a poorly-developed process that employed hot water to separate oil and sand, the company still managed to recover several thousand barrels of tar to be sold in Edmonton as roofing material. The same year, a Research Council of Alberta scientist, Dr. Karl Clark set up an experimental pilot



The Athabasca region is a sea of scrub trees and muskeg atop oil-soaked tar sands. For years men have tried to extract the oil economically

The Horse River plants of Abasand Oils Limited, an early attempt at commercial production of the sands, burned down in 1945





Syncrude's early test site by the Athabasca River at Mildred Lake helped the company decide on a full-scale plant. The camp unit is still used

plant to develop an efficient hot water method of separating the oil from the sand. His work eventually formed the basis for large-scale production using that process.

In 1936, Abasand Oils Limited ordered construction of a 250-ton-per-day separation plant just southwest of Fort McMurray on the Horse River. A year later they started a second plant, this one capable of processing 400 tons each day. Throughout the summer of 1941 the plants extracted 17,000 barrels of bitumen from the sands. But that fall the plants burned. Abasand rebuilt their project the following year, but what fire couldn't destroy, a lack of finances did. In 1943 the federal government took over the Horse River plants. A 100-ton-per-day pilot plant grew from the original works and in 1945 an additional 500-ton-per-day separation plant rose on the site. But oil sands were never processed in the plants; fire destroyed them both in 1945.

Enthusiasm for development of the tar sands waned after 1947 with the discovery of large reserves of conventional oil in Alberta. But despite this setback to the tar sands, pilot plant operations were re-started in 1948 by the Research Council of Alberta and throughout the 1950s laboratory scientists and backyard inventors continued to look for better ways to bring out the oil. As research carried into the 1960s, hot water separation still proved best.

At this period it was becoming clearer that world supplies of conventional crude oil could not meet the ever-increasing demand. New sources of oil and ultimately new sources of energy would have to be found. As science began accelerated study of the atom and the sun, the Canadian oil industry concentrated more of its efforts on the tar sands. In 1967, near Ruth Lake, a large-scale plant using a combination of mining and Dr. Clark's hot water separation method took the first steps towards efficient production of synthetic crude oil from the Athabasca tar sands.

If tar sands development continues over the next five to 10 years, additional extraction plants will likely be designed around the mining method. 'The technology has already been developed for it,' says Imperial Oil's Syncrude coordinator, Jim Wunder.

At a mining site on the tar sands the method will be open-pit – continuously exposed to the sky and to nature. While

basically a simple process, tar sands mining is an enormous undertaking, and the size of the undertaking causes many difficulties. The economics of the operation depend on a steady flow of tar sands 'ore' through the mining and extraction process but even before the process can begin, overburden must be stripped off the sand – a big undertaking itself. Once the overburden is removed, giant earth movers, clanking about the pit floor, can dig into the abrasive sand. Wear on equipment is high; in the harsh winters of northern Alberta, where temperatures can fall to 60 degrees below zero, the ground is much harder and the rate of this wear and tear increases.

Once removed, the sands are dropped on conveyor belts or unit trains and taken to the nearby extraction plant. The Syncrude operation envisages mining in excess of 300,000 tons of sand every day, enough to fill a train of 100-ton gondola cars 24 miles long.

Inside such a plant a multi-staged process will bring out the bitumen, destined to become oil. In the first stage of extraction the oil-coated sand enters a drum where hot water and steam are added to produce a slurry. The oily froth is skimmed off the top of the mixture and dried. Then the dried material is converted into synthetic crude oil. In this last process sulfur is extracted from the bitumen, making the crude environmentally acceptable. The synthetic crude is shipped out to market through a network of pipelines.

The spent sand and water, called tailings, present a major disposal problem. At Syncrude these 'tailings' will eventually be returned to the mined-out area and future plans call for landscaping and re-planting on the returned sand. But during the first years of production such a move would simply crowd out the huge mining machines. In the early years a surface tailings pond will be used to collect the refuse and the water will be re-cycled back to the plant. To meet environmental standards the water used in the process will be confined to recycling in the plant and none of it will go into the Athabasca River.

Construction of the Syncrude plant will create some 3,000 jobs. When the plant starts producing crude a permanent staff of more than 1,600 will keep it running. Additional jobs would be created in Alberta by the supply and service needs of the plant. Says Syncrude's Don



Scott, manager of employee relations: 'This spin-off factor would create at least 8,000 more jobs in Alberta.'

One of the benefactors of this increased activity would be Fort McMurray. Prior to construction of Great Canadian Oil Sands, the town had fewer than a thousand residents. A sleepy hamlet, it took its livelihood from trapping, lumbering and some river transportation. As GCOS went through the construction stage and finally into start-up the town's population jumped to 6,000. Since then it has risen to nearly 8,000 accompanied by the institutions and services vital to a modern community.

'The arrival of Syncrude would more than double the town's present population,' says Scott. 'If others follow, Fort McMurray could well become one of the largest cities in the Canadian Northland.'

As it grows, the town will produce a large additional demand for such basic services as housing, transportation and education. 'It's quite an undertaking,' says Scott, 'but we're doing everything in our power to make sure that these services are provided.'

Another problem facing Syncrude is the cost of the plant facilities. In mid-1971 its cost was estimated at \$350 million. But inflated construction costs have pushed the plant's price tag close to the \$800 million mark. 'There are also large preproduction costs that we incur before the project becomes fully operative,' says Jim Wunder. 'As a result there is a race between the plant cost and the price of crude. If construction costs outrun crude prices then companies trying to develop the tar sands would not be able to go ahead.'

'On top of this,' he adds, 'are the problems of obtaining an adequate labor supply as well as sufficient risk capital. Investors are not often eager to put money into projects that take a long time to build and provide a slow return on investment.'

Despite the apparent drawbacks, industry experts, confident that crude prices will rise, are predicting that between 10 and 15 huge plants will be at work on the tar sands by 1990. 'By 1980 we can expect 250,000 to 300,000 barrels of synthetic crude from the tar sands every day,' says Wunder. 'By 1990 the figure could reach 1½ million barrels per day.'

Much of this forecast production is



Sample chunks of oil-rich, coarse-grained tar sands look, smell and feel like the asphalt used to pave city streets. Widespread in the Athabasca region, sands underlie 12,000 square miles

A vein of extra-rich oil sand runs through a formation in the Mountain Rapids area of the tar sands. The sands, varying often in quality, are a mixture of sand, water and bitumen





Bulldozers clean up tar sands spilled by the huge dragline at Syncrude's Mildred Lake facility. Equipment handling the highly-abrasive earth wears out quickly, especially in winter.

tied to the recovery of oil from the deeply-buried deposits. Over the last decade, oil company researchers have attempted to devise an efficient and economical method of recovery from these deep sands. The methods they are developing work on a principle similar to the ones currently used to increase oil production from conventional operations. When an oil-bearing formation is reached by drilling, the oil is forced to the surface by some form of stored energy. The energy can be pressure from gas dissolved in the oil itself, from a 'cap' of compressed gas above the oil, or a head of water beneath it. Frequently the energy source runs out when only a fraction of the oil is recovered, leaving 80 per cent or more of the crude still locked in the rock formation. Some source of energy must be applied from the surface to recover as much of the remaining oil as practical. In conventional recovery, injection wells force water or natural gas down into the oil zone, displacing the crude. In the tar sands, the oil will have to be made less viscous as well before it can be forced out. Among the methods proposed to liquefy it are controlled underground fire, steam injection, emulsion injection and underground atomic explosion. Then it can be forced to the surface like conventional oil. At its Cold Lake facilities 140 miles northeast of Edmonton Imperial has been active in this kind of research since 1964. This pilot project, which involves the use of heat from steam injection to reduce viscosity, has been producing small volumes of oil for some time. The size of this pilot project will be expanded in the near future.

According to Jim Wunder it is unlikely that any significant production will come from these deeply-buried sands before 1980. But, he adds, 'The oil is there in great quantities. Just one successful demonstration of acceptable production and costs will set the stage for commercial development.'

'As the world price of crude oil increases, development of the tar sands is coming within our reach,' Wunder believes. 'Every day the oil industry gets a little closer to the technology that will unlock a large portion of the tar sands. Future developments will be running hard to stay abreast of demand. And the number of tar sands production plants may be limited only by the capital and the manpower available to build them.'

Some Plain Words about Prices and Profits

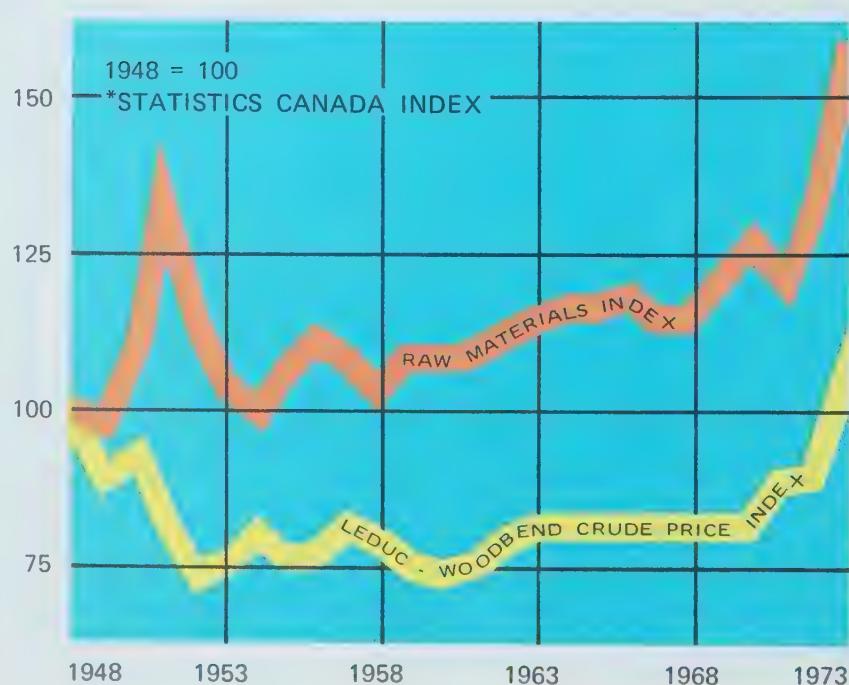
by J. A. Armstrong, President, Imperial Oil Limited

On Sept. 4 the federal government announced its intention to isolate Canadian crude oil prices from U.S. influences and suggested to the oil industry that prices of some petroleum products be "frozen" in Canada until Jan. 30, 1974, with certain exceptions. Imperial Oil is complying with this request.

Many people have assumed from the government's action that petroleum prices are too high and, by extension, that recent oil company profits are too large. Such notions are easily reached, especially if the relevant facts are ignored, and once they take hold they are hard to shake. There would be little matter for concern in this if notions did not lead to attitudes, and attitudes to demands for action that may be neither necessary nor fruitful. Here are some facts about prices and profits in Imperial and the Canadian oil industry.

First, I want to describe what has happened to prices. It is no news to anybody that they have been rising.

PRICE TRENDS: TYPICAL ALBERTA CRUDE OIL AND RAW MATERIALS IN GENERAL*



In the past year, gasoline has increased by about five cents per gallon at the pump, mainly because the costs of crude oil have increased from the depressed levels that persisted for several decades. Today, the supply of oil is tight throughout the world, and oil-producing countries have raised their prices, thus increasing the value of oil as a commodity. As a country that imports and exports crude oil, Canada has followed suit, raising the price of Canadian crude to reflect the higher value placed on it by international markets.

Measured against the long term, these increases have not been spectacular. In October the price of a typical Alberta crude oil – our raw material – was only 16 per cent higher than it was 25 years ago. In comparison, the composite price of industrial raw materials generally has increased 58 per cent in the same period.

The prices of petroleum products have risen lately, reflecting the increased costs of crude oil to refiners. Some comparisons may help you to decide whether they have risen too much.

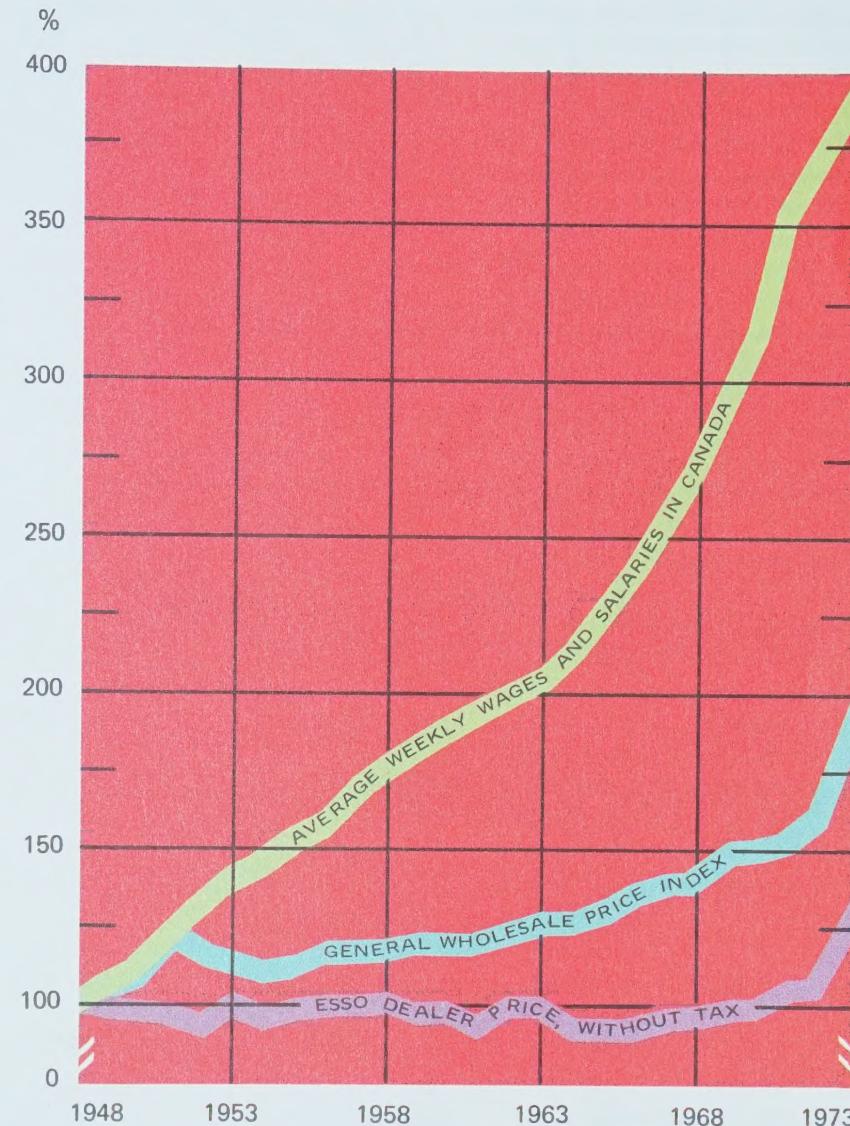
On the average, the price Imperial receives for Esso gasoline – the wholesale price at which the company sells it to the dealer, exclusive of federal and provincial taxes – has increased 21 per cent since 1948. In the same period the General Wholesale Price Index has increased about 95 per cent. Average weekly wages and salaries have increased by almost 400 per cent.

To put it another way, in 1948 the Canadian wage earner had to work 25 minutes to buy a gallon of gasoline. Today, he works eight minutes, and today's gasoline is vastly superior to the product he bought in 1948.

Furthermore, Imperial gets less than half the amount the motorist pays at the pump; the rest is dealer margin and taxes. And taxes take the lion's share of the balance. Today, the combined federal and provincial tax on gasoline ranges from 17.8 cents per gallon in Alberta and British Columbia to 28.1 cents in Newfoundland. The amount Imperial gets ranges from 24.5 cents to 27.8 cents.

Imperial's profits have been rising too, and some critics say they are too high. This is a matter we must all judge for ourselves. Some facts about Imperial's profits and those in the

ESSO DEALER PRICE WITHOUT TAX COMPARED WITH GENERAL WHOLESALE PRICE INDEX AND WAGES AND SALARIES INDEX



industry may help in reaching conclusions.

It should be understood first that the oil business is a high-risk business. Imperial, for example, spent 30 years exploring the three prairie provinces before discovering Leduc in 1947. The search cost \$23 million, an enormous amount in those days. Since the Canadian oil industry began exploring the Atlantic shelf in 1960, it has risked \$300 million. There have been some encouraging signs, but hydrocarbons in commercial quantities have yet to be found.

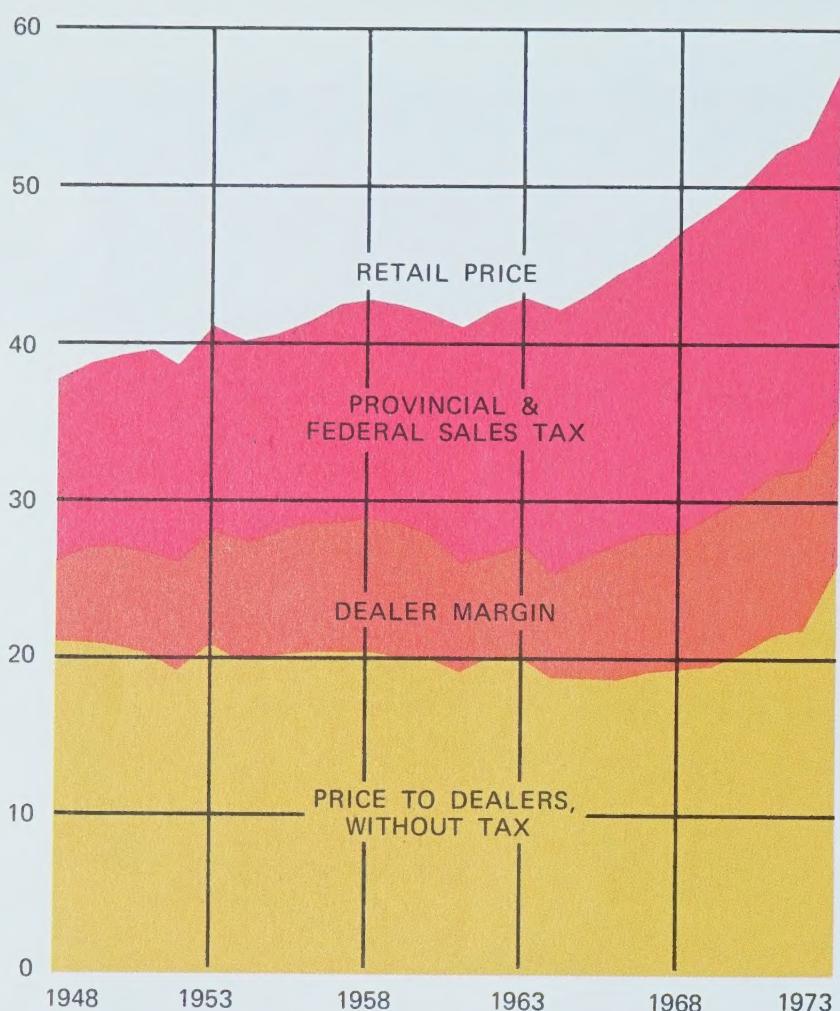
And the risks are not all in the exploration end of the business. Imperial's modernization and expansion program at Sarnia refinery ran into technological

difficulties so severe that they were a major factor in the company's reduced earnings performance in 1969. To go outside Imperial's experience, a company that has been operating a plant in the Athabasca tar sands for the past six years has reported losses totaling \$88 million so far.

The Canadian oil industry made an after-tax profit in 1972 of 7.4 per cent on the money it used in its business. The after-tax profit in manufacturing generally that year was 7.3 per cent – essentially the same return in an industry that, by normal standards, is considered to face less risk.

Under these circumstances, you might wonder why anyone would invest in such a risky business as oil,

WHO GETS WHAT FROM THE SALE OF A GALLON OF ESSO GASOLINE



particularly in the very-high-risk exploration phase. The answer is that they hope the company in which they invest will turn in a better-than-average earnings performance. And that brings us to Imperial Oil.

Imperial is a large company with large revenues, and it deals in large product volumes. It ranks third in Canada in dollar volume of sales – last year it sold more than \$2 billion worth of goods and services. Its assets total \$1.79 billion. Its capital employed – in essence, its total assets less its current liabilities – is more than \$1.5 billion.

In absolute terms, these are very large figures. In absolute terms, the company's profit is also a very large figure. Last year the profit was \$151 million.

But to consider Imperial's profit only in absolute terms is not very enlightening. By itself, the figure tells nothing about the size of the investment on

which it is based, nor the efficiency of the company.

A more meaningful way to look at a company's profit is in terms of how much it earned on total revenue. In 1972, Imperial's profit on each dollar was 7.3 cents, which is just about the company's average of the past 25 years. The high was 8.9 cents in 1955, and the low was six cents in 1958.

Because Imperial makes so many products from the same barrel of crude oil, it is impossible to state exactly what profit the company makes per gallon of any specific product. Nevertheless, about half of the company's revenue comes from the sale of petroleum products, and the profit from this source amounts to a little less than one-and-a-quarter cents per gallon on all petroleum product sales.

Another measure of a company's profitability is the return it makes on the capital it has employed. Imperial's

return last year was 11.1 per cent, virtually the same return it made in 1956. But the company's return dropped off after that year, and it has taken until now to get it back to the 1956 level. Earnings in 1972 were more than double the 1956 amount; but so was the capital employed. The size of the profit has kept pace with the size of the investment, which is the least a company should strive for; ideally it should achieve a return in keeping not only with the investment increase, but also with the risk involved.

Imperial's profits have increased so far in 1973, reflecting the company's increased production and sale of crude oil and significant improvements in chemical markets. Crude oil production and sale was the main factor, and profits from this aspect of the business have been criticized as "windfalls" – a term whose current definition includes a suggestion that the beneficiary is not entitled to them.

The "windfall" concept also suggests that today's sales are being made without any increase in costs. In fact, Imperial spent more than \$100 million over the past five years on the expansion of its production facilities in anticipation of increased markets.

The crude Imperial is now producing was discovered many years ago – in some cases it is coming from wells drilled more than a quarter of a century ago. In the intervening years, the amount of crude Imperial was permitted to produce was limited by market prorationing to such an extent that the company could not even supply the needs of its own refineries. Furthermore, the crude that Imperial was allowed to produce was sold at prices depressed by the market conditions of those days. The revenue the company is receiving now from increased sales at higher prices is, in effect, delayed profits.

And for every additional dollar that comes to Imperial from crude price increases, approximately 82 cents stays in Canada. Out of this, 49 cents goes to governments and the remainder is distributed to Canadian shareholders or re-invested.

In examining prices and profits, it should be remembered that a rise in price may be painful to the consumer today, but it has an effect that will work to his advantage in a way that isn't immediately apparent – it will

keep him warm in winters to come by stimulating the development of new energy sources.

Canada has abundant potential energy resources. The Geological Survey of Canada estimates that the energy contained in this country's remaining reserves of fossil fuels is equivalent to the energy of about 1,000 billion barrels of oil. (Fossil fuels include crude oil produced by conventional methods, natural gas, oil from the Athabasca tar sands, heavy oil from the Cold Lake region of Alberta, and coal.)

But, compared with the past, Canada's potential energy resources today are either geographically remote or technologically much more demanding — or both. Therefore, if these resources are to be turned into useable energy, we will have to meet greater costs.

Take coal for example. The technology has been developed to make coal non-polluting — and to make it much cheaper to transport — by turning it into synthetic crude oil or synthetic gas. But, according to the federal government's publication *An Energy Policy for Canada*, crude oil would have to sell for \$5 to \$7 a barrel before gasified or liquified coal could

become feasible alternatives to conventional oil or gas. Today, a barrel of typical Alberta crude sells for just under \$4 at the wellhead.

Exploration in the frontier areas provides another example of the higher costs of energy resource development today. To drill an exploration well in Alberta today costs from \$50,000 to \$1 million — the average is about \$150,000. To drill on the mainland in the Arctic costs at least \$2 million a well and most of them cost a good deal more. Imperial spent \$5 million on an artificial island before the Arctic's first offshore well could be drilled. To drill offshore in the Atlantic costs some \$3.5 million per well.

The costs of developing nuclear energy are even greater, per unit of energy, than the costs of developing hydrocarbons. Nevertheless, *An Energy Policy for Canada* forecasts that supplies from this source will grow by as much as 80 times by the end of this century.

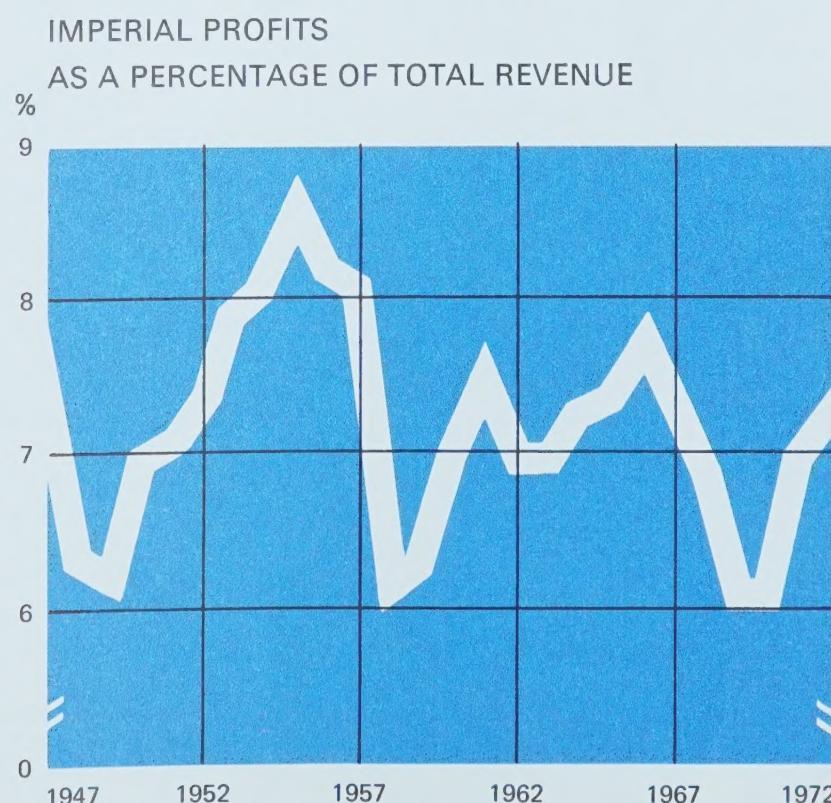
The tremendous cost of developing our energy potential means that energy prices must be high enough to provide an incentive that matches the risk involved. This will help to ensure sufficient energy for future generations of Canadians. The opposite is also

true; keeping the price of oil down will inhibit or stop completely the development of the new, costlier sources of energy. Artificially low prices will also encourage greater consumption of our conventional reserves, leading to inefficient and even wasteful use.

This is the larger question of energy supply. Canada is blessed with bountiful sources of energy, but without an incentive to risk the very large amounts required to develop them, they will not be developed.

Prices can stimulate this development where they reflect the true value of the commodity, or inhibit it where they are unrealistically low. This is what happened in the United States when the price of natural gas was pegged so low that exploration for new reserves virtually ceased and the low prices stimulated wasteful consumption.

I know that, as the president of Canada's largest oil company, I am in an awkward position to be arguing the merits of a policy that would appear to be to Imperial Oil's advantage. As a Canadian citizen I am concerned about the security of our supplies of crude oil and petroleum products today, and about Canada's energy requirements tomorrow. □



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Assistant Editor/Steve Lynett
Designer/Bill Williamson
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